

## Methods to Define Pre-Primacy Field Boundaries

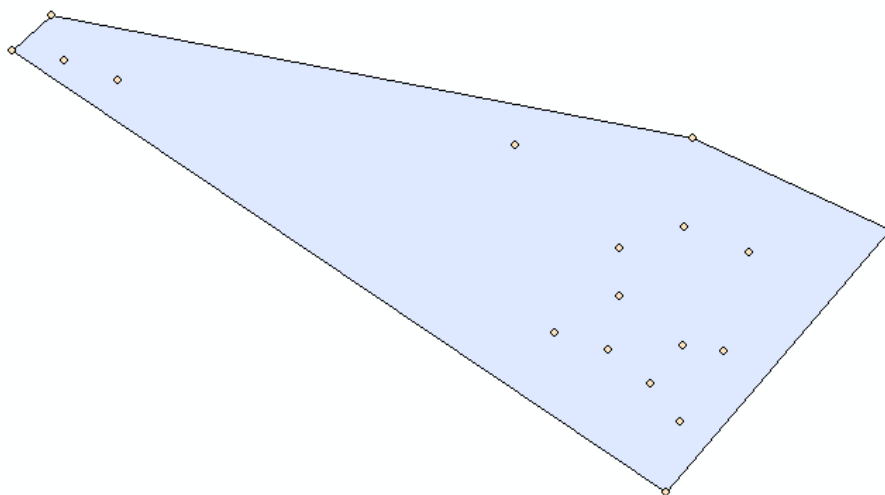
### Introduction

By letter to EPA dated March 21, 1982 (see Appendix I), the Commission agreed to furnish EPA with maps of “productive fields within the State of Texas.” At that time, the only field maps that we are aware were available to the Commission were published by the Bureau of Economic Geology (BEG) at the University of Texas at Austin. BEG published a document titled “Energy Resources of Texas 1976” (Univ. of Tx, Austin, Bur. Econ. Geol., ERM Maps, 1976, Scale 1:1,000,000), which depicted, but did not name, the mapped fields. The BEG also published an “Atlas of Major Oil Reservoirs” in 1983 and an “Atlas of Major Gas Reservoirs” in 1989. These maps provided the horizontal extent of all productive fields in the state.

As part of this aquifer exemption project, the Commission evaluated several methods to determine field boundaries and used two methods to draw boundaries of pre-primacy oil and gas fields based on the location of wells completed in the field on or before April 23, 1982.

### Geometric Method

The Geometric Method creates the smallest convex polygon enclosing the input points (oil and gas wells completed on or before April 23, 1982.) The polygon generated by the Geometric Method outlines the perimeter of wells in the field (see Figure 1).



*Figure 1 Example field using Geometric Method. Yellow markers represent well locations.*

One disadvantage of the Geometric Method is that a single well far away from other wells will significantly change the shape of the polygon. To minimize this impact, the Commission excluded any single well located greater than 10 miles away from all other wells in the field.

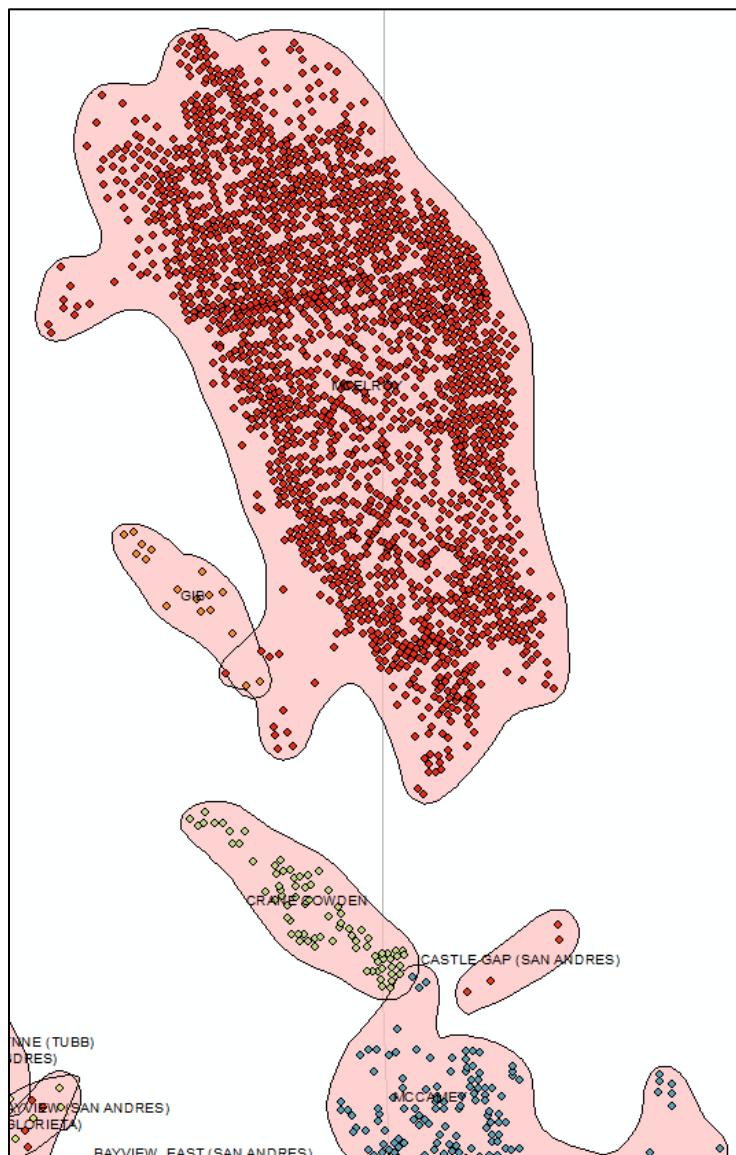
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In addition, this method can overlook some arcs and bends of field shapes, particularly in large fields. For example, in a large field where the wells form a “C” shape, the Geometric Method would fill in the area within the “C.”

### The Wyoming Method

The Wyoming State Geological Survey (WSGS) has developed a method for automating the development of maps of Wyoming oil and gas fields. The method used by WSGS (the Wyoming Method) was described in an article, entitled Automating Oil and Gas Field Mapping in Wyoming, in the Winter of 2017 edition of ArcNews, published by ESRI. The Commission contacted WSGS and obtained the information needed to recreate the Wyoming Method.

Figure 2 depicts example field boundaries generated by the Wyoming Method.



*Figure 2 Example field boundaries generated by the Wyoming Method.*

### The Modified Wyoming Method

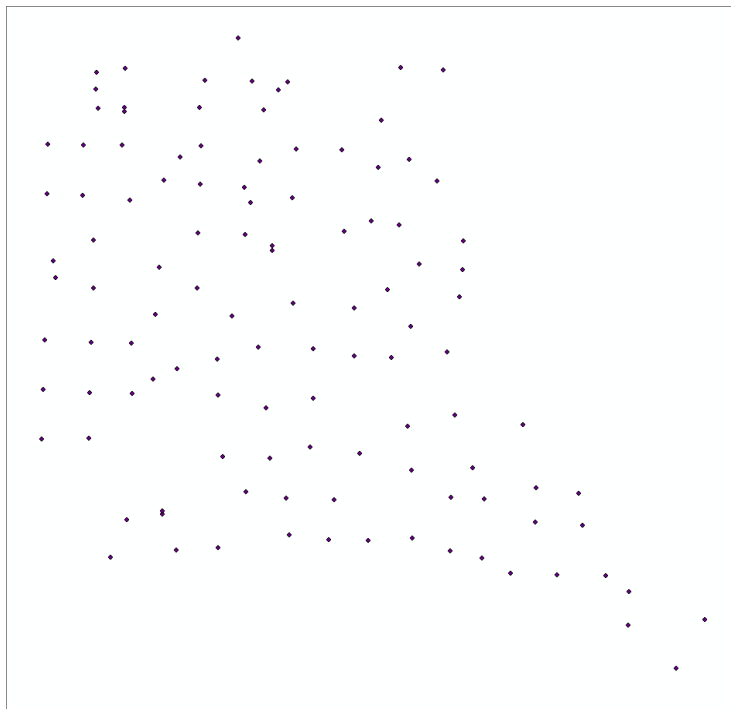
The Commission created a cartographic model to define field boundaries largely based on the model obtained from the Wyoming State Geological Survey. The modified method uses a series of buffering, aggregation, simplifying, and smoothing steps to generate representations of the fields. The Commission modified Wyoming's base model by applying the ArcGIS tool "Eliminate Polygon Part" to fill in any holes in a field under 10 square miles.

Compared to the Geometric Method, the Modified Wyoming Method accounts for more wells when drawing the field shape, creating a tighter fit of the field shape to the wells. This effect is more pronounced in larger fields.

### Details

The following is a high-level explanation of the processes used to build field shapes using the Modified Wyoming Method.

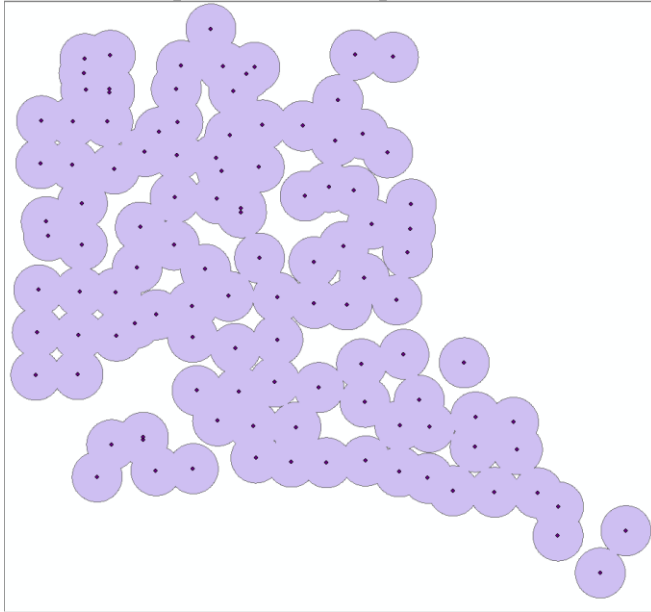
Figure 3 shows well locations in a specific field.



*Figure 3 Well Locations: Wells in the GOMEZ (ELLENBURGER) Field.*

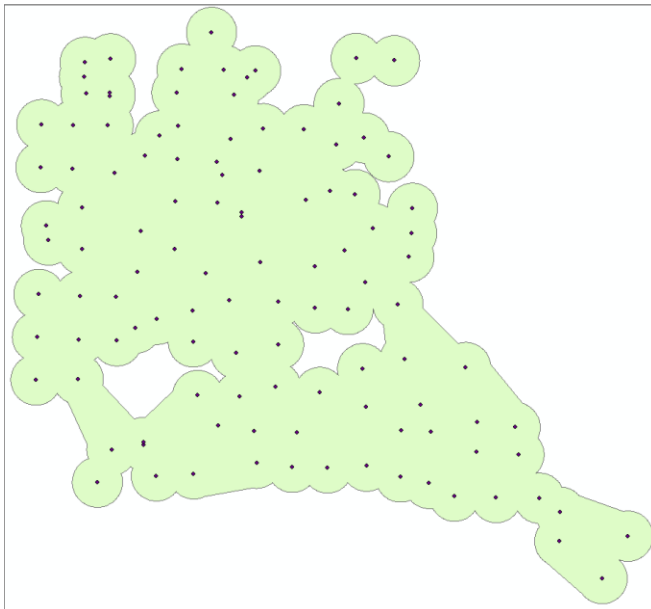
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In accordance with the Modified Wyoming Method, circles with a radius of 0.6 miles are then drawn around each well and the space is combined where the circles overlap (see Figure 4).



*Figure 4 Buffer & Dissolve Points.*

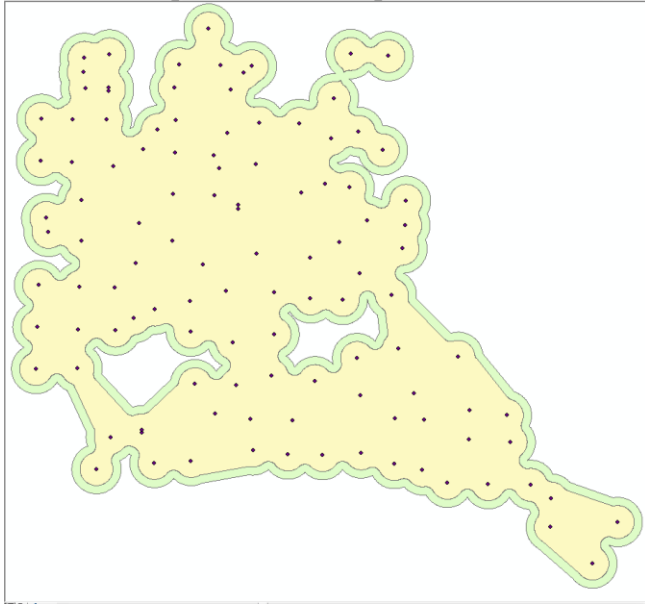
In accordance with the Modified Wyoming Method, circles within 1.3 miles of each other are then aggregated (Figure 5).



*Figure 5 Aggregate Polygons.*

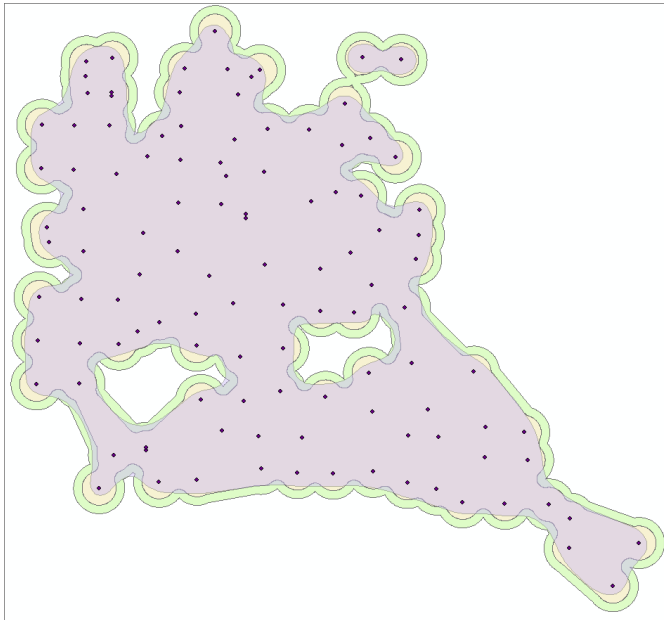
In accordance with the Modified Wyoming Method, the 0.2-mile buffer is then removed to better fit the field shape defined by the wells in the field.

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*Figure 6 Buffer (0.2 miles) removed.*

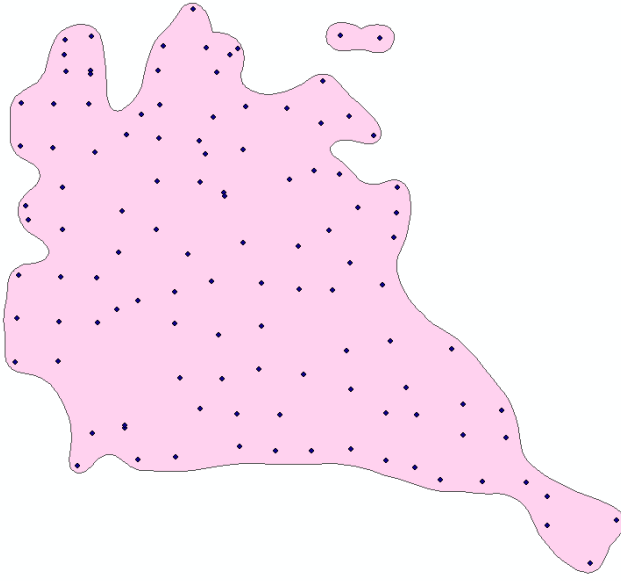
In accordance with the Modified Wyoming Method, the edges of the circles are then smoothed (Figure 7).



*Figure 7 Simplify & Smooth Polygons.*

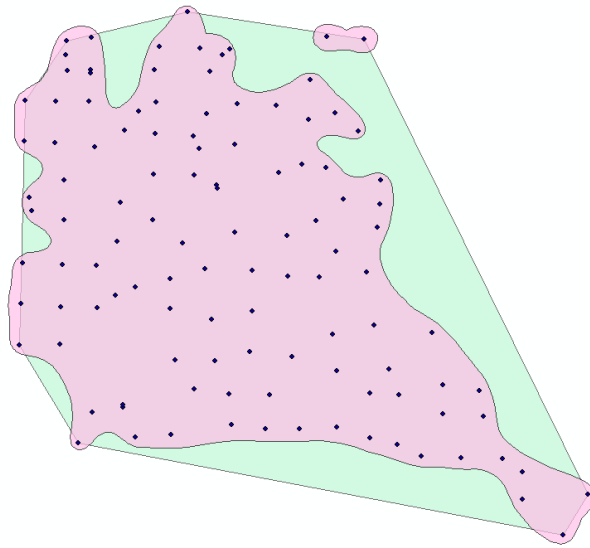
The “holes” in the field are then filled in (Figure 8).

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*Figure 8 Reduce Polygon Holes*

Figure 9 shows a comparison of the results of the Geometric Method and the Modified Wyoming Method. The Modified Wyoming Method has a built-in buffer. Due to the complexity of the method, there are variations in the distance from boundary wells to the field shape edge.



*Figure 9 Comparison of the Geometric Method and Modified Wyoming Method (Geometric Method is in aqua. Modified Wyoming Method is in pink.)*

### Finding UIC Permits Outside of Field Boundaries

To locate injection wells in an expanded area of a pre-primacy field, the Commission used the following criteria:

- Active UIC permit
- UIC Type 2 or 3
- Permitted after April 23, 1982
- Permitted in pre-primacy fields
- Potentially into strata containing water with a total dissolved solids (TDS) concentration of less than 10,000 mg/l

The field boundaries created by the Geometric Method were buffered by ½ mile. The field boundaries created by the Modified Wyoming Method were buffered by 0.15 miles to create a boundary approximately ½ mile from each field's perimeter wells. An ArcGIS tool, Intersect Analysis, was then used to analyze thousands of permitted wells meeting the above criteria to determine which permitted wells were outside of the resulting boundaries. Any permitted wells outside of the boundary of the field as determined using the Geometric Method or the Modified Wyoming Method were identified for individual review.

The use of both methods to identify permitted wells outside of pre-primacy field boundaries minimized the potential issues associated with each individual method.